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REVIEW ARTICLE

Environmental impact assessment of pesticide use, using environmental impact quotient

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SUMMARY: Environmental impact assessment (EIA) may be defined as a formal process used to predict the environmental consequences of any development project. Environmental assessment identifies potential problems and opportunities and is thus an essential part of assessment. By itself, however, it is insufficient for decision making. As mentioned earlier, the economic and financial analysis helps the planner to decide among possible options so as to eliminate or reduce negative environmental effects in a cost effective manner. Balancing costs and benefits, private and public considerations, are those where difficult decisions have to be taken. Environmental impact quotient organizes the pesticide information that is active ingredient, rate of application of pesticides into a usable form to help growers and other practitioners make more environmentally sound pesticide choices. The values obtained from these calculations can be used to compare different pesticides and pest management programmes to ultimately determine which programme or pesticide is likely to have the lower environmental impact.

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Environmental impact assessment (EIA) may be defined as a formal process used to predict the environmental consequences of any development project. EIA thus ensures that the potential problems are foreseen and addressed at an early stage in the projects planning and design. Three criteria for identifying significant impacts on the environment were suggested in the world conservation strategy.

- Criterion would include an assessment of the number of people affected, how much of a particular resource would be degraded, eliminated or – depending on what action is taken – conserved (Lois, 2000).
- Urgency – It is important to establish just how quickly a natural system might deteriorate and how much time is available for its stabilization or enhancement (Myrick Freeman, 1999).
- The degree of irreversible damage to communities of plants and animals, to life – support systems, and to soil and water (Dixon *et al.*, 1986).

EXPERIMENTAL METHODOLOGY

Measurement of environmental impacts :

***Environmental impact quotient* :**

This method organizes the pesticide information that is active ingredient, rate of application of pesticides into a usable form to help growers and other IPM practitioners make more environmentally sound pesticide choices. The values obtained from these calculations can be used to compare different pesticides and pest management programmes to ultimately determine which programme or pesticide is likely to have the lower environmental impact .

The EIQ equation :

The formula for determining the EIQ value of individual pesticides is listed below and is the

Table A : The rating system used to develop the environmental impact quotient of pesticides (EIQ) model 1 = least toxic or least harmful, 5 = most toxic or harmful

Mode of action	Toxicity to fish-96 hr LC50
Non-systemic- 1	> 10 ppm - 1
All herbicides - 1	1 to10 ppm - 3
Systemic - 3	< 1 ppm - 5
Acute Dermal LD50 for	Toxicity to birds-8 day LC50
rabbits/rats(mg)	> 1000 ppm - 1
>2000 - 1	100 to1000 ppm - 3
200 to 2000 - 3	1to100 ppm - 5
0 to 200 - 5	
Long-term health effects	Toxicity to bees
Little or none - 1	Relatively nontoxic - 1
Possible- 3	Moderately toxic - 3
Definite - 5	Highly toxic - 5
Plant surface residue half-life	Toxicity to Beneficials
l to 2 weeks- 1	Low impact- 1
2 to4 weeks- 3	Moderate impact - 3
> 4 weeks - 5	Severe impact - 5
Pre-emergent herbicides - l	
Post-emergent herbicides - 3	
Soil residue half-life	Groundwater and runoff Potential
$T_{1/2}$ = <30 days - 1	Small - 1
$T_{1/2}$ = 30 to100 days - 3	Medium - 3
$T_{1/2}$ = >100 days - 5	Large -5

Source: Kovach *et al.* (1995).

average of the farm worker, consumer and ecological components.

$$EIQ = \{C[(DT * 5) + (DT * P)] + [(C * ((S + P)/2 * SY + (L)]+) [F * R) + (D * ((S + P)/2) * 3) + (Z * P * 3) + (B * P * 5)]\}/3$$

DT = dermal toxicity,
C = chronic toxicity,
SY = systemicity,
F = fish toxicity,
L = leaching potential,
R = surface loss potential,
D = bird toxicity,
S = soil half-life,
Z = bee toxicity,
B = beneficial arthropod toxicity,
P = plant surface half-life.

Farm worker component :

Farm worker risk is defined as the sum of applicator exposure (DT* 5) plus picker exposure (DT*P) times the long-term health effect or chronic toxicity (C). Chronic toxicity of a specific pesticide is calculated as the average of the ratings from various long-term laboratory tests conducted on small mammals. These tests are designed to determine potential reproductive effects (ability to produce offspring), teratogenic effects (deformities in unborn offspring), mutagenic effects (permanent changes in hereditary material such as genes and chromosomes), and oncogenic effects (tumor growth). Within the farm worker component, applicator exposure is determined by multiplying the dermal toxicity (DT) rating to small laboratory mammals (rabbits or rats) times a coefficient of five to account for the increased risk associated with handling concentrated pesticides. Picker exposure is equal to dermal toxicity (DT) times the rating for plant surface residue half-life potential (the time required for one-half of the chemical to break down). This residue factor takes into account the weathering of pesticides that occurs in agricultural systems and the days to harvest restrictions that may be placed on certain pesticides.

The consumer component :

Is the sum of consumer exposure potential (C*((S+P)/2)*SY) plus the potential groundwater effects (L). Groundwater effects are placed in the consumer component because they are more of a human health issue (drinking well contamination) than a wildlife issue. Consumer exposure is calculated as chronic toxicity (C) times the average for residue potential in soil and plant surfaces (because roots and other plant parts are eaten) times the systemic potential rating of the pesticide (the pesticide's ability to be absorbed by plants).

The ecological component :

Of the model is composed of aquatic and terrestrial effects and is the sum of the effects of the chemicals on fish (F*R), birds (D*((S+P)/2)*3), bees (Z*P*3), and beneficial arthropods (B*P*5). The environmental impact of pesticides on aquatic systems is determined by multiplying the chemical toxicity to fish rating times the surface runoff potential of the specific pesticide (the runoff potential takes into account the half-life of the chemical in surface water).

After the data on individual factors were collected, pesticides were grouped by classes (fungicides, insecticides/miticides, and herbicides), and calculations were conducted for each pesticide. When toxicological data were missing, the average for each environmental factor within a class was determined, and this average value was substituted for the missing values. Thus, missing data did not affect the relative ranking of a pesticide within a class.

EXPERIMENTAL FINDINGS AND DISCUSSION

The results obtained from the present investigation have been discussed under following heads:

EIQ field use rating :

Once an EIQ value has been established for the active ingredient of each pesticide, field use calculations can begin. To accurately compare pesticides and pest management strategies, the dose, the formulation or per cent active ingredient of the product, and the frequency of application of each pesticide needs to be determined. To account for different formulations of the same active ingredient and different use patterns, a simple equation called the EIQ field use rating was developed. This rating is calculated by multiplying the EIQ value for the specific chemical obtained in the tables by the per cent active ingredient in the formulation by the rate per acre used (usually in pints or pounds of formulated product).

EIQ field use rating = EIQ x % active ingredient x rateofapplication

With this method, comparisons of environmental impact between pesticides and different pest management programmes can be made. For example, if several pesticides can be used against a particular pest, which pesticide is the least toxic choice? Table 1 shows the example comparing the environmental impact of three insecticides: carbaryl (Sevin 50WP), endosulfan (Thiodan 50WP), and azinphos-methyl (Guthion 35WP). Although carbaryl has a lower EIQ (22.6) than endosulfan (40.5) or azinphos-methyl (43.1), it may take more of it to provide equivalent control. For example, 6 lbs/acre of Sevin may provide the same level of control of a certain pest as 3 lbs/acre of Thiodan or 2.2 lbs/acre of Guthion. In this situation, Guthion would have the lowest EIQ field use rating (33 .2) and would be the least toxic choice. Thiodan (60.8) would be the second choice and Sevin (67.8) would be the last.

By applying the EIQ field use rating, comparisons can be made between different pest management strategies or programmes. To compare different pest management programmes, EIQ field use ratings and number of applications throughout the season are determined for each pesticide. And these values are then summed to determine the total seasonal environmental impact of the particular strategy.

Table 2 compares the theoretical environmental impact of several different pest management approaches that have been used in research projects to grow 'Red Delicious' apples in New York. In this example, a traditional pest management approach to growing 'Red Delicious' apples that does not rely heavily on pest monitoring methods would result in a total theoretical environmental impact of 938 due to pesticides.

An IPM approach that incorporates pest monitoring methods, biological control, and least toxic pesticides would have an environmental impact of only 167 (Table 3). By using the EIQ model, it becomes possible for IPM practitioners to

Table 1: Eexample showing the EIQ field use rating of three different insecticides to determine which pesticide should be the least toxic choice

Material	EIQ	AI	Rate	EIQ field use rating
Sevin 50WP (carbaryl)	22.6	0.50	6.0	67.8
Thiodan 50WP (endosulfan)	40.5	0.50	3.0	60.8
Guthion 35WP (azinphos-methyl)	43.1	0.35	2.2	33.2

Source: Kovach *et al.,* (1995). EIQ= Environmental impact quotient, AI = Active ingredient

Table 2: Traditional pest management strategy

Material	EIQ	AI	Dose	Applications	Total
Rubigan EC	27.3	0.12	0.6	4	8
Captan 50WP	28.6	0.50	3.0	6	257
Lorsban 50WP	52.8	0.50	3.0	2	158
Thiodan 50WP	40.5	0.50	3.0	2	61
Guthion 35WP	43.1	0.35	2.2	2	66
Cygon 4E	74.0	0.43	2.0	3	191
Omite 6EC	42.7	0.68	2.0	2	116
Kelthane 35WP	29.9	0.35	4.5	1	47
Sevin 50WP	22.6	0.50	1.0	3	34
Total environmental impact					938

Source: Kovach *et al.,* (1995). EIQ= Environmental impact quotient, AI = Active ingredient

Table 3: Integrated pest management (IPM) strategy

Material	EIQ	AI	Dose	Applications	Total
Nova 40WP	41.2	0.40	0.3	4	20
Captan 50WP	28.6	0.50	3.0	1	43
Dipel 2X	13.5	0.06	1.5	3	4
Sevin 50WP	22.6	0.50	3.0	1	34
Guthion 35WP	43.1	0.35	2.2	2	66
Total environmental impact					167

Source: Kovach *et al.,* (1995). EIQ= Environmental impact quotient, AI = Active ingredient

rapidly estimate the environmental impact of different pesticides and pest management programs before they are applied, resulting in more environmentally sensitive pest management programmes being implemented.

Challenges in assessing environmental impacts :

In this section we shift from describing possible environmental impacts of agriculture to discussing some of the challenges and potential difficulties which researchers face in developing systems to assess these impacts. These are conceptual challenges which are not, for the most part, likely to have quick technical solutions. The issues we discuss are organized into three sections.

– The identification and integration of environmental indicators;
– The bias against future impacts or, alternatively, our greater ease and ability in measuring and assessing current and tangible impacts; and
– The reality of data limitations, which constrain the development of assessment models in covering the breadth of environmental parameters

Other limitations include :

– Lack of theory, explanatory paradigms, and basic understanding.
– Inadequate monitoring of parameters of environmental conditions.
– Sampling and analytical errors.
– Lack of baseline environmental data at a project site.
– Models that do not completely correspond to reality because they cannot consider all variables and must be simplified.
– The novelty of technology and materials.
– Inherent variation and stochastic events in complex natural systems and.
– Control and replication problems in ecological research.

Conclusion :

Environment impact quotient organizes the pesticide information into a single value for environmentally sound pesticide choices. Though it does not give information in monetary terms, it helps in decision making by considering various components like farm worker component, consumer component and ecological component.

In environmental impact assessment, there are several hurdles like selection and quantification, inherent randomness of complex natural systems, data limitations, etc. All the methods discussed here, solely or together help in decision making. Still, there is a need to develop more comprehensive environmental impact assessment tools.

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